

MEASUREMENT OF THE CROSS SECTIONS AND ANALYZING POWERS FOR TRANSITIONS IN ^{58}Ni USING 200 MeV PROTON SCATTERING

J. Lisantti, A. D. Bacher, G.P.A. Berg, S. M. Bowyer, S. Chang,
E. Hull, J. Liu, C. Olmer, E. J. Stephenson, S. P. Wells,
S. W. Wissink, and S. Young
Indiana University Cyclotron Facility, Bloomington, Indiana 47408

K. H. Hicks
Ohio University, Athens, Ohio 45701

The run from Feb. 8 to Feb. 15, 1991 was mainly devoted to E340, a study of transitions in ^{58}Ni . Elastic and inelastic scattering data were taken using the external beam dump for angles from 15° to 50° in 2.5° steps and at 55° , 60° , and 65° . These data covered the range from the ground state up to ~ 15 MeV in excitation energy. The resolution obtained was 25–30 keV. Figure 1 presents data taken at 40° .

Of particular interest are four 6^+ transitions that are predicted to arise from single particle-hole excitations. Previous proton scattering experiments¹ have observed only one state located at 5.13 MeV. Comparisons to DWIA calculations showed a normalization dependence on beam energy between 178 and 800 MeV. This was attributed to deficiencies in the central and spin-orbit terms in an older version of the Love-Franey force.² A new analysis of the 6^+ state at 5.13 MeV using a more recent Love-Franey force applied to data taken at 280 and 489 MeV showed no energy dependence.³ However, this later work used data taken with poor energy resolution (~ 160 keV), and this may contribute to errors in the measured cross sections. We will further investigate these states using the new data.

Electron scattering data have been taken at NIKHEF⁴ for this nucleus. From this data, both charge and current transition densities have been obtained for a large number

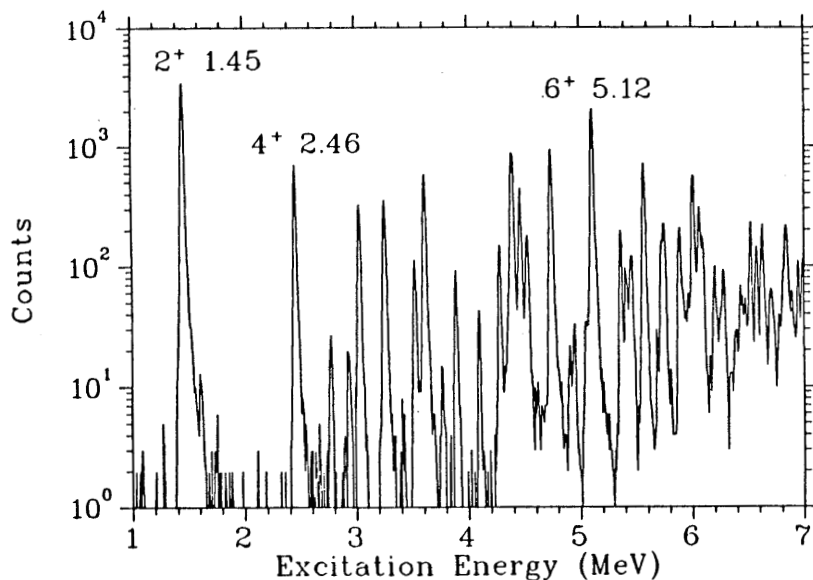


Figure 1. Spectrum taken at 40° for 200 MeV polarized proton scattering from ^{58}Ni with spin up.

of natural parity states ranging from 2^+ to 6^+ excitations. Using these results, along with an empirical effective interaction obtained by Kelly and co-workers at 200 MeV,⁵ we hope to obtain neutron transition densities for the states that we observe in common with (e,e').

Using electron scattering, Lindgren *et al.*⁶ have observed five magnetic 8^- states in the excitation energy range between 7.9 and 12.5 MeV. These states contained 23% of the strength predicted in shell model calculations. This quenching of strength appears to be a property of magnetic states in a variety of nuclei. Figure 2 shows our data at 37.5° covering an excitation energy range which contains the 8^- states. We clearly observe the T=2, 8^- state located at 12.50 MeV as observed in the electron work. However, our high resolution spectrum suggests that this structure is not a single peak and that it may contain other states. At the lower excitation energies the level density is quite high, as can be seen in Fig. 2, and will require a more careful energy calibration in order to identify these states.

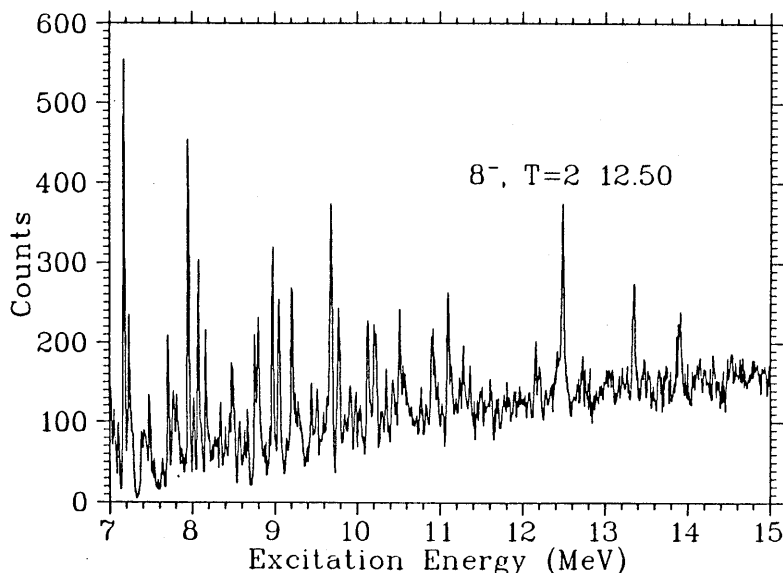


Figure 2. Spectrum taken at 40°, for spin up, emphasizing the region of the 8^- states. The T=2, 8^- state observed in (e,e') scattering at an excitation energy 12.50 MeV is clearly observed in the present work.

In order to check normalizations that are used in calculating absolute cross sections, we have obtained yields for the ground state and for the first excited state at 1.45 MeV. Cross sections and analyzing powers were then obtained for these two states at all angles. An optical model fit was then done to the elastic data employing Woods-Saxon shaped potentials using the code ECIS79. This fit to the elastic cross section and analyzing power is shown in Fig. 3. The parameters obtained are: $V_R=10.52$ MeV, $r_R=1.3307$ fm, $a_R=0.5842$ fm, $V_I=30.5152$ MeV, $r_I=0.9561$ fm, $a_I=0.8489$ fm, $V_{RSO}=3.9314$ MeV·fm², $r_{RSO}=0.9670$ fm, $a_{RSO}=0.7060$ fm, $V_{ISO}=-2.4484$ MeV·fm², $r_{ISO}=0.9859$ fm, and $a_{ISO}=0.5596$ fm. Using these parameters and employing the collective deformed potential model, we calculated the cross section for the 2^+ , 1.45 MeV state. These calculated cross sections were scaled to match the data. The scaling parameter is the hadronic deformation length (δ_H). This parameter is related to the reduced transition probability (B(EL)) for that state. It

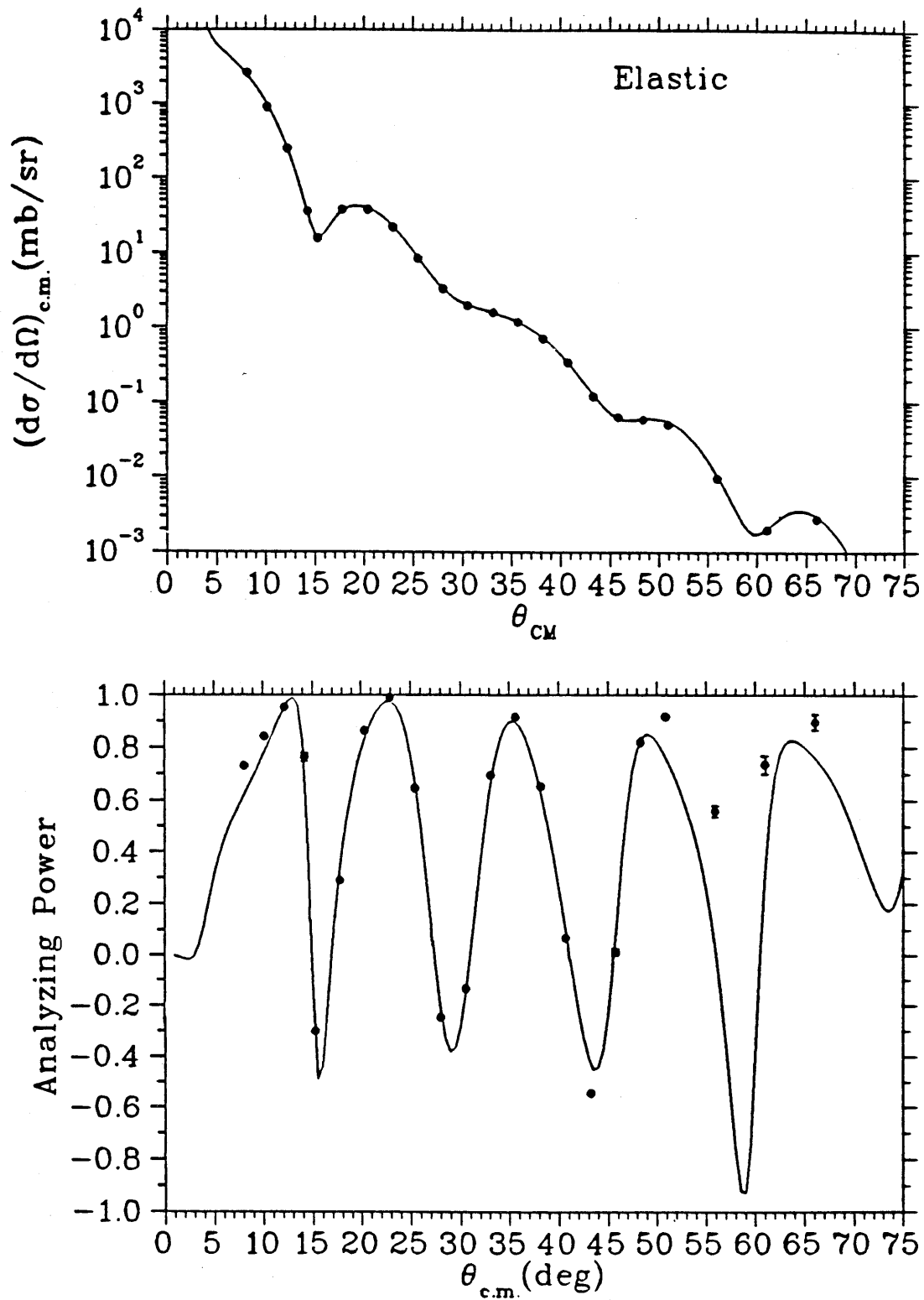


Figure 3. Elastic scattering cross section and analyzing power data for 200 MeV protons on ^{58}Ni . The solid lines represent nonrelativistic optical model fits to the data.

has been shown⁷ that the hadronic deformation length is constant as a function of incident beam energies for a variety of collective states in ^{58}Ni . The value of δ_H for the 2^+ , 1.45 MeV state determined using protons in the energy range of 178 to 1047 MeV is 0.82 ± 0.04 . Figure 4 presents our data for this state using $\delta_H = 0.84$. As is observed the data are described quite well by the calculation. This strongly suggests that the normalization for each angle is well determined and that reliable cross sections and analyzing powers will be obtained. Where the data and the calculations do not agree (at the larger angles) there are probably inadequacies in the collective model, such as the assumption that the neutron and proton transition densities are the same, or problems due to the use of a zero-range force.

At the present time we are in the process of extracting yields for the majority of states. As Figs. 1 and 2 show, this will require some time. We hope to have final results by the summer of 1992.

- 1) N. M. Hintz, *et al.*, Phys. Rev. **C30**, 1976 (1984).
- 2) W. G. Love and M. A. Franey, Phys. Rev. **C24**, 1073 (1981).
- 3) Jerry E. Lisantti, accepted for publication, Nucl. Phys. **A**.
- 4) Hans Blok, Ph.D. dissertation, Vrije Universiteit te Amsterdam, 1986.
- 5) J. J. Kelly, private communications.
- 6) R. A. Lindgren, *et al.*, Phys. Rev. Lett. **40**, 504 (1978).
- 7) J. Lisantti, *et al.*, Nucl. Phys. **A511**, 643 (1990).

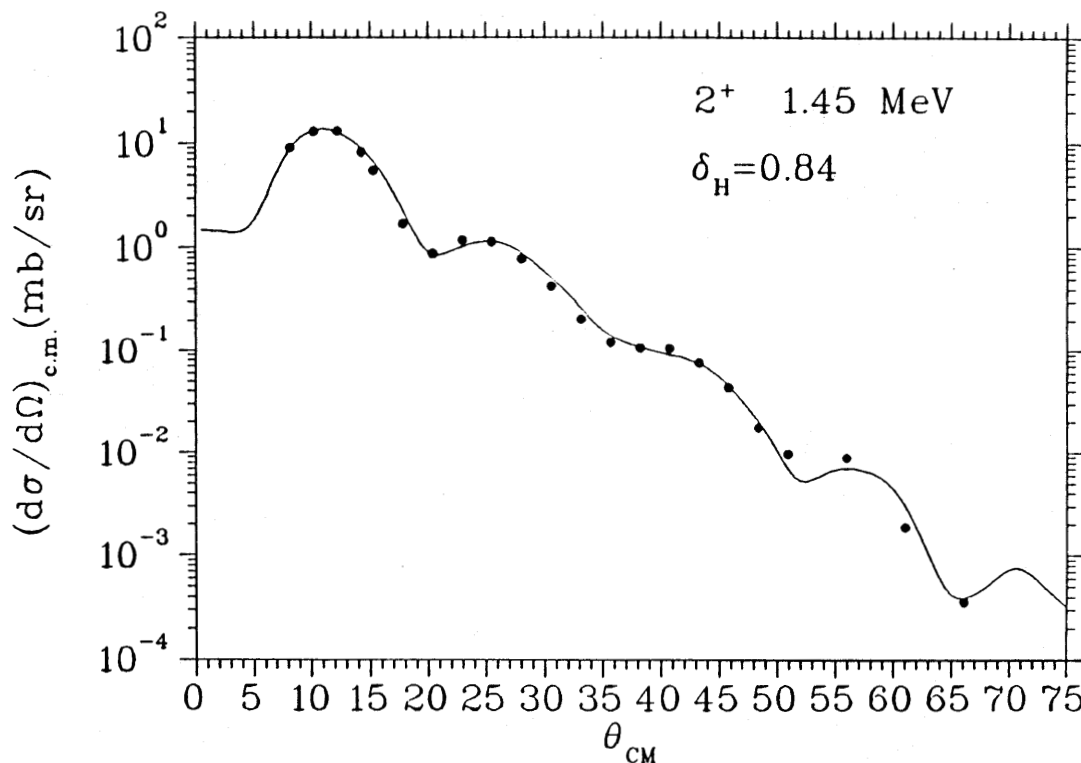


Figure 4. Inelastic scattering cross section data for the 2^+ , 1.45 MeV state in ^{58}Ni . The solid line is a deformed collective model calculation scaled to the data with $\delta_H = 0.84$.